Landsat Ecosystem Disturbance Adaptive Processing System

LEDAPS: Assessing Forest Disturbance from Landsat Imagery

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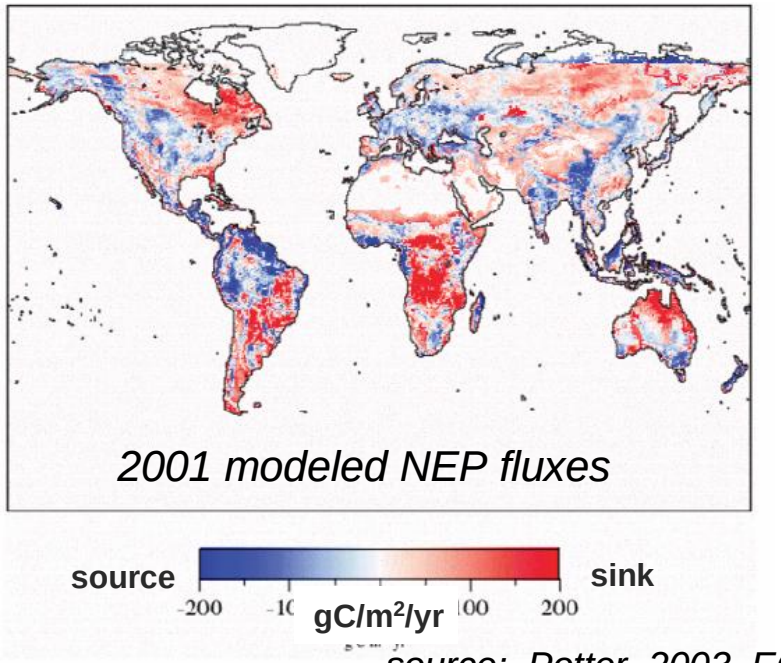
Background

Global estimates of carbon fluxes often exclude effects of land cover change and disturbance

Patch size often small – requires Landsat-type data analysis

NACP Science Plan calls for analysis of disturbance from satellite data



2001 modeled NEP fluxes

source: Potter, 2003, EOS

1985 1988 1999

Two Related Projects

LEDAPS (Landsat Ecosystem Disturbance Adaptive Processing System): Wall-to-wall disturbance patterns, 1990-2000, mapped from ~2200 TM/ETM+ scene pairs.

=> spatial patterns; gross rates

UMD NACP Project: Sampling approach (25 U.S. locations) with dense time series of imagery

=> precise rates, temporal variability

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LEDAPS Goals

• Generate decadal surface reflectance (SR) product for North America from Landsat GeoCover archive (1975-2000)

  • *apply lessons from MODIS processing*

• Generate **decadal, wall-to-wall** maps of forest disturbance, recovery, and conversion for **North America** in support of NACP

  •*high-resolution (30m) scene-based products*

  •*coarse-resolution (0.05 deg) modeling products*

• Develop automated approaches to Landsat processing that can be adapted for other community applications

  • *we do this for AVHRR, MODIS, VIIRS… why not Landsat?*

•Work with representatives of USDA Forest Service to evaluate applications utility of SR and disturbance products for carbon management and forest monitoring.

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LEDAPS Processing Overview

Landsat TM, ETM+

Landsat MSS

- Calibration
- Atmospheric Correction
- Cloud/Snow masking

- Radiometric Normalization

Radiometrically Consistent Surface Reflectance Dataset (1975-2000)

Preprocessing

Analysis

MODIS Products

- Disturbance Rate via Disturbance Index
- Biophysical change from canopy reflectance model

Aggregation

QA/ Validation

Disturbance/Recovery Products for Carbon Assessments

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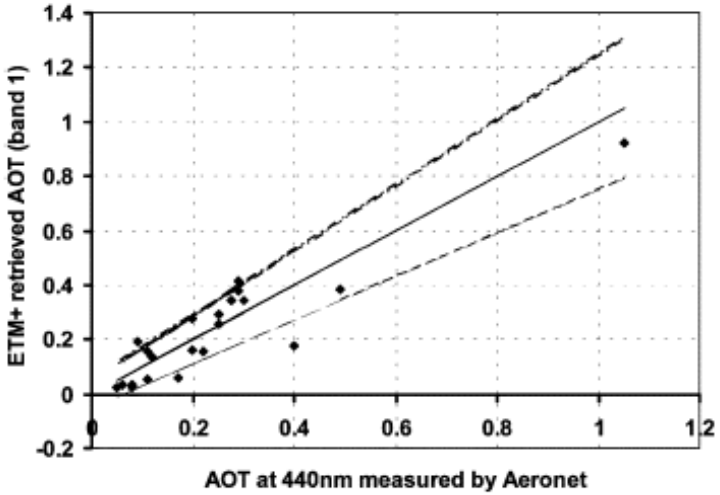
Atmospheric Correction

Based on MODIS/6S radiative transfer approach

water vapor from NCEP re-analysis data
ozone from TOMS, EP-TOMS
topographic-dependent Rayleigh correction

Aerosol optical thickness estimated from imagery using the Kaufmann et al (1997) "Dense, dark vegetation" approach

- estimate blue reflectance based on TOA SWIR 2
- difference between TOA_{blue} and SR_{blue} gives AOT
- interpolate valid targets across image



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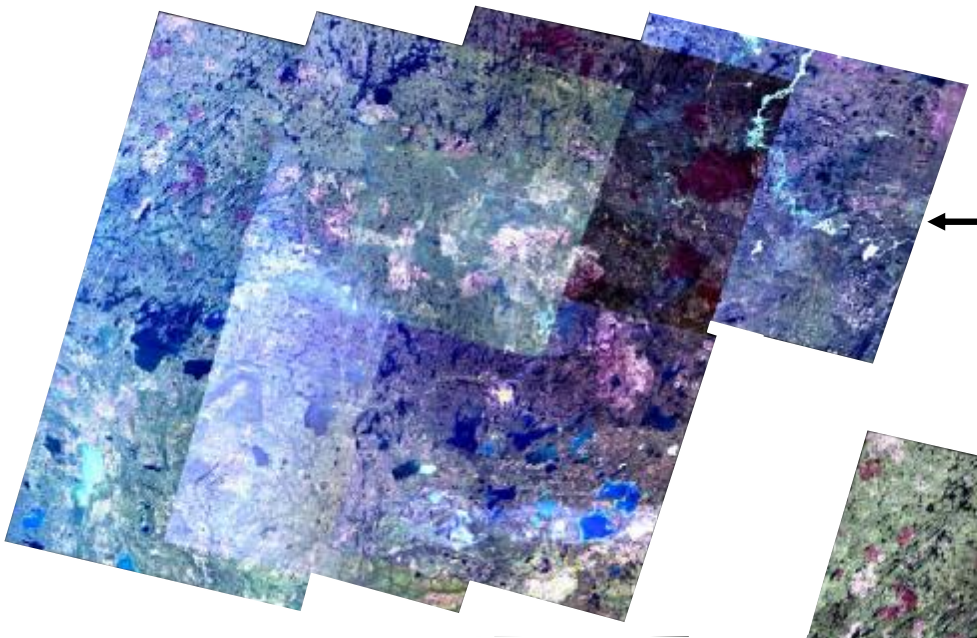
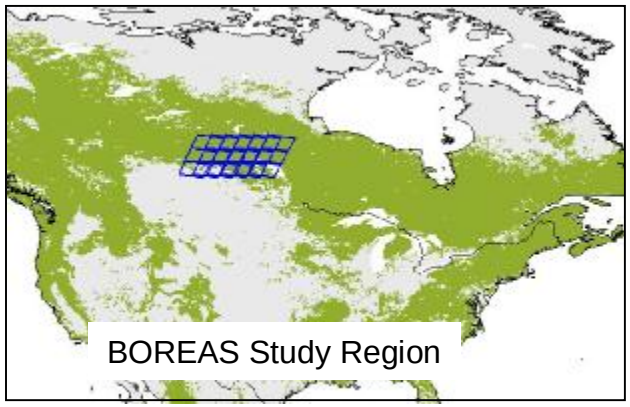
Atmospheric Correction

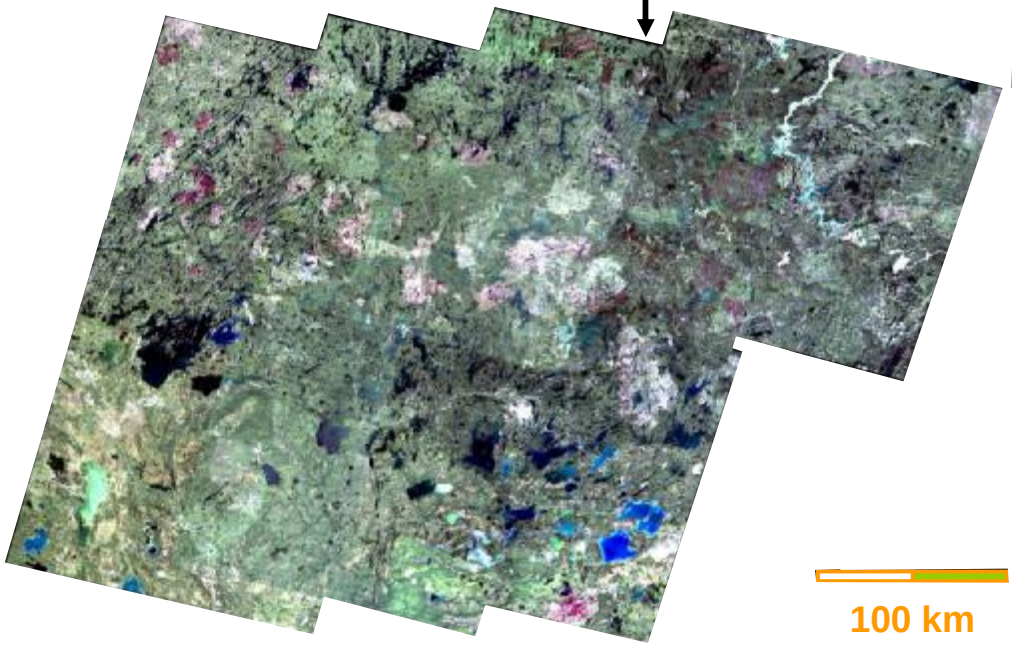
1990's Landsat-5 mosaic

TOA reflectance

Surface reflectance



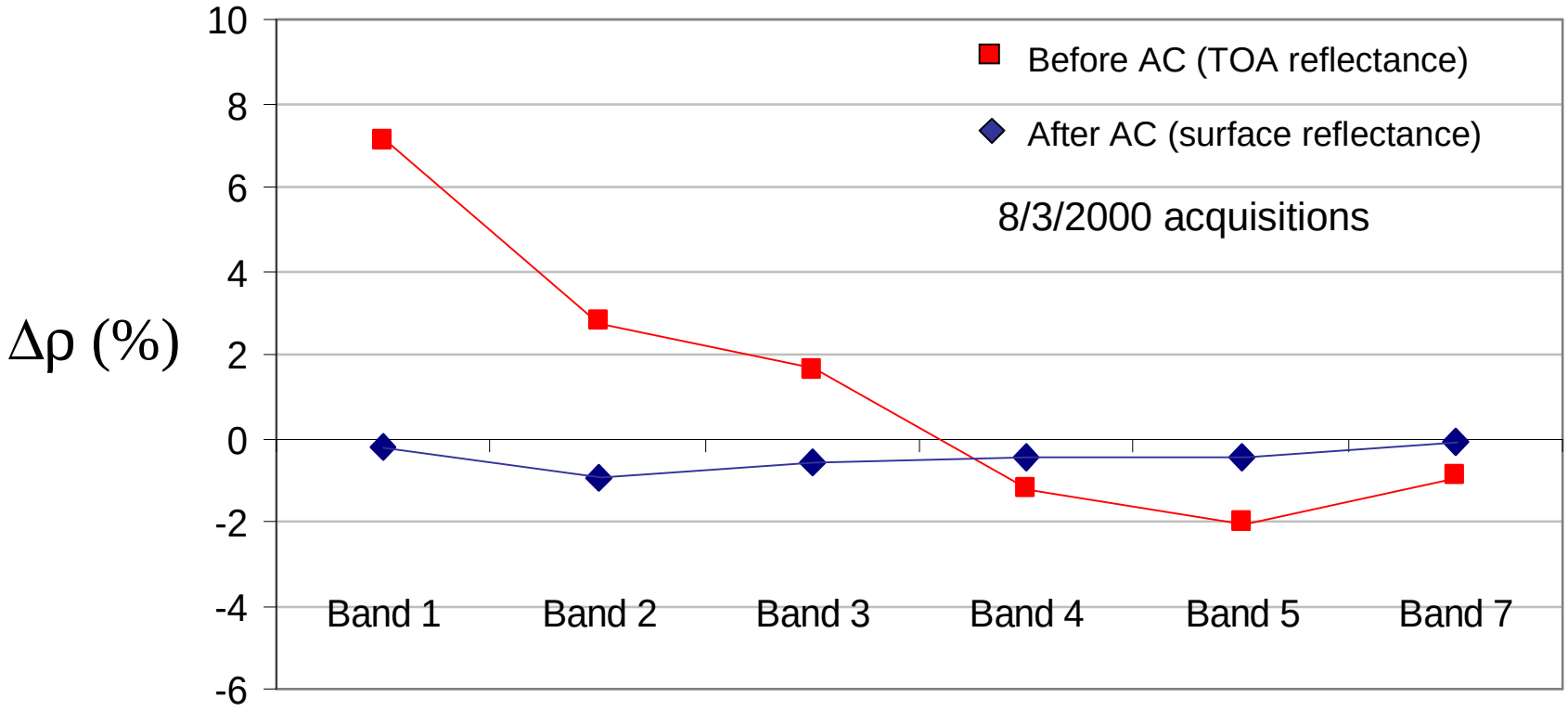




100 km

Effect of Atmospheric Correction

(MOD9A surface reflectance) – (ETM+ reflectance), 8/3/00



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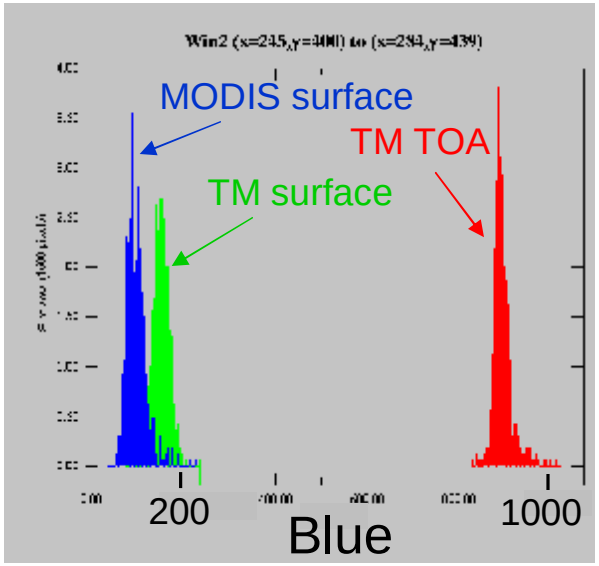
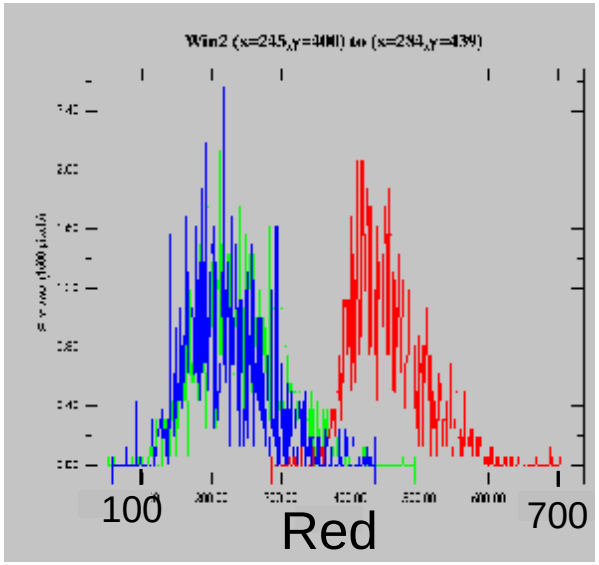
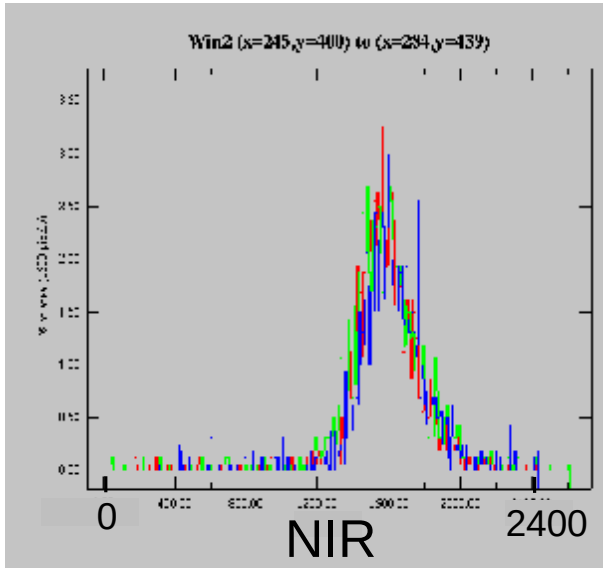
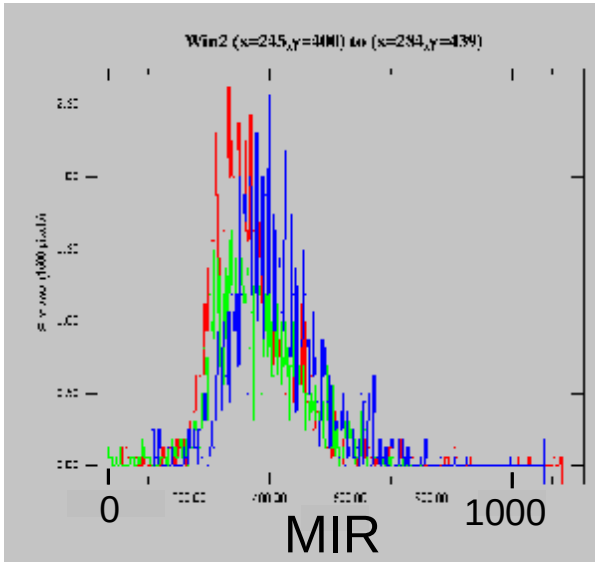
Reflectance Validation

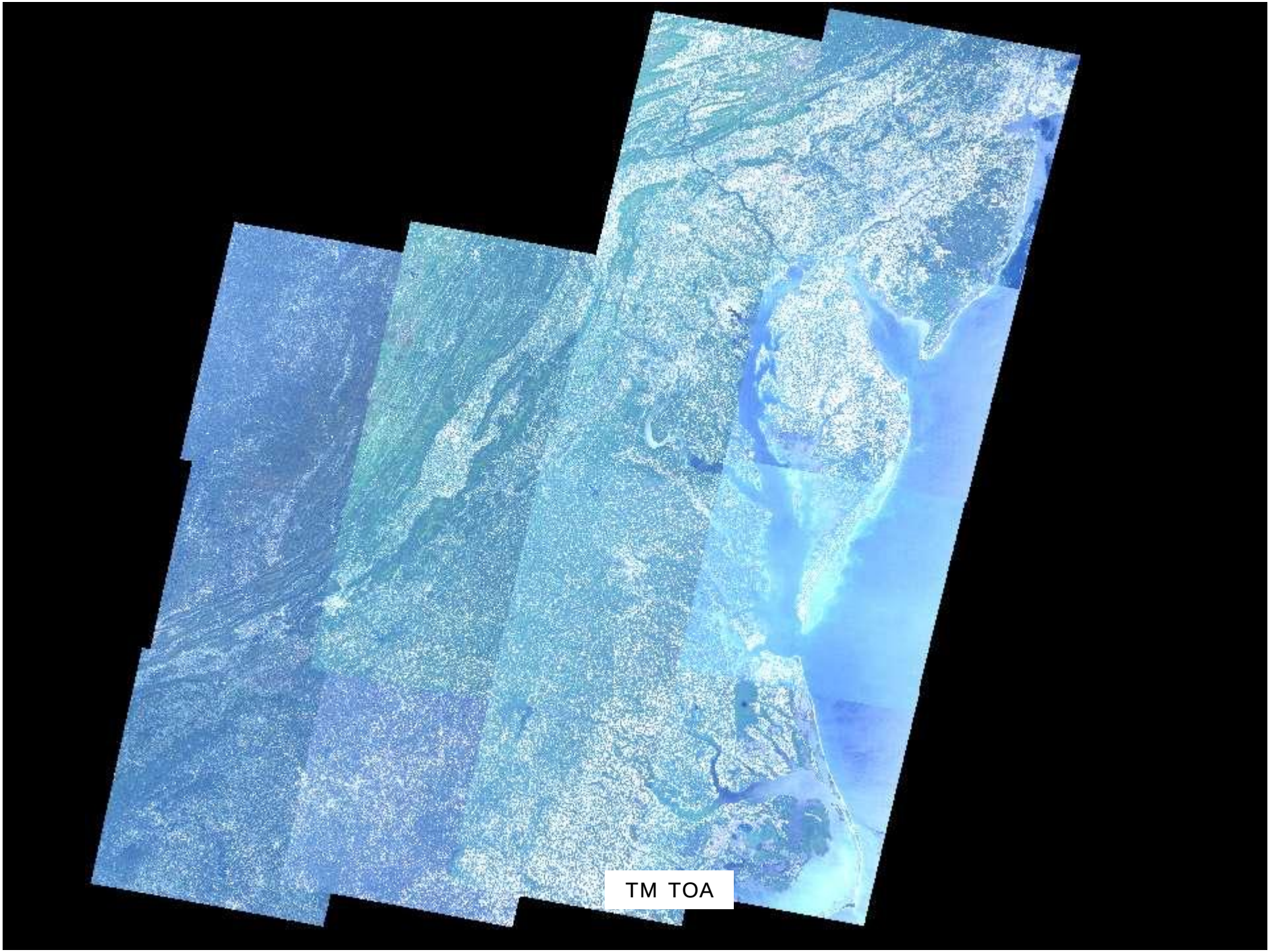


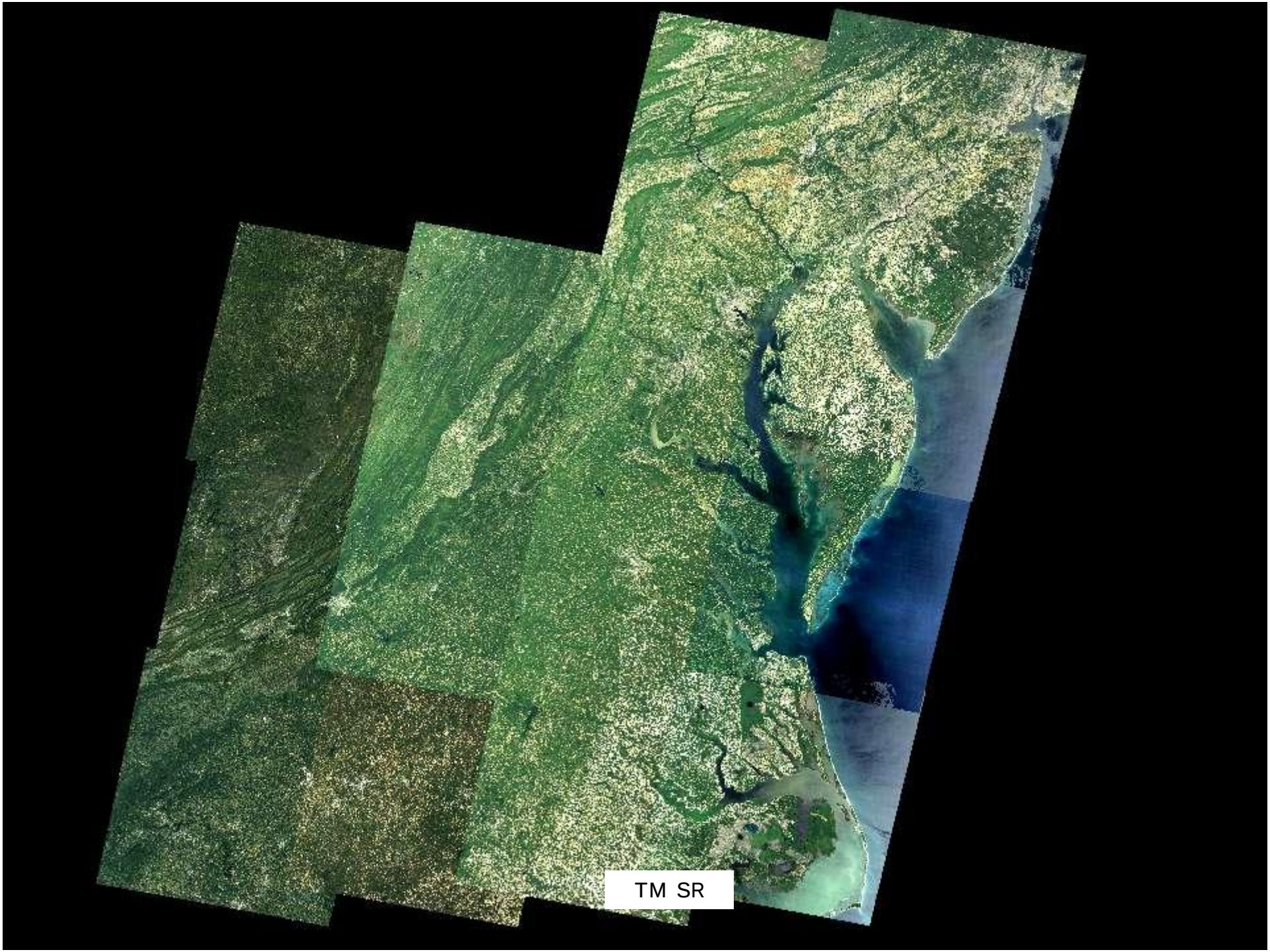






Units:
Reflectance
(x 10000)


TM TOA


TM SR

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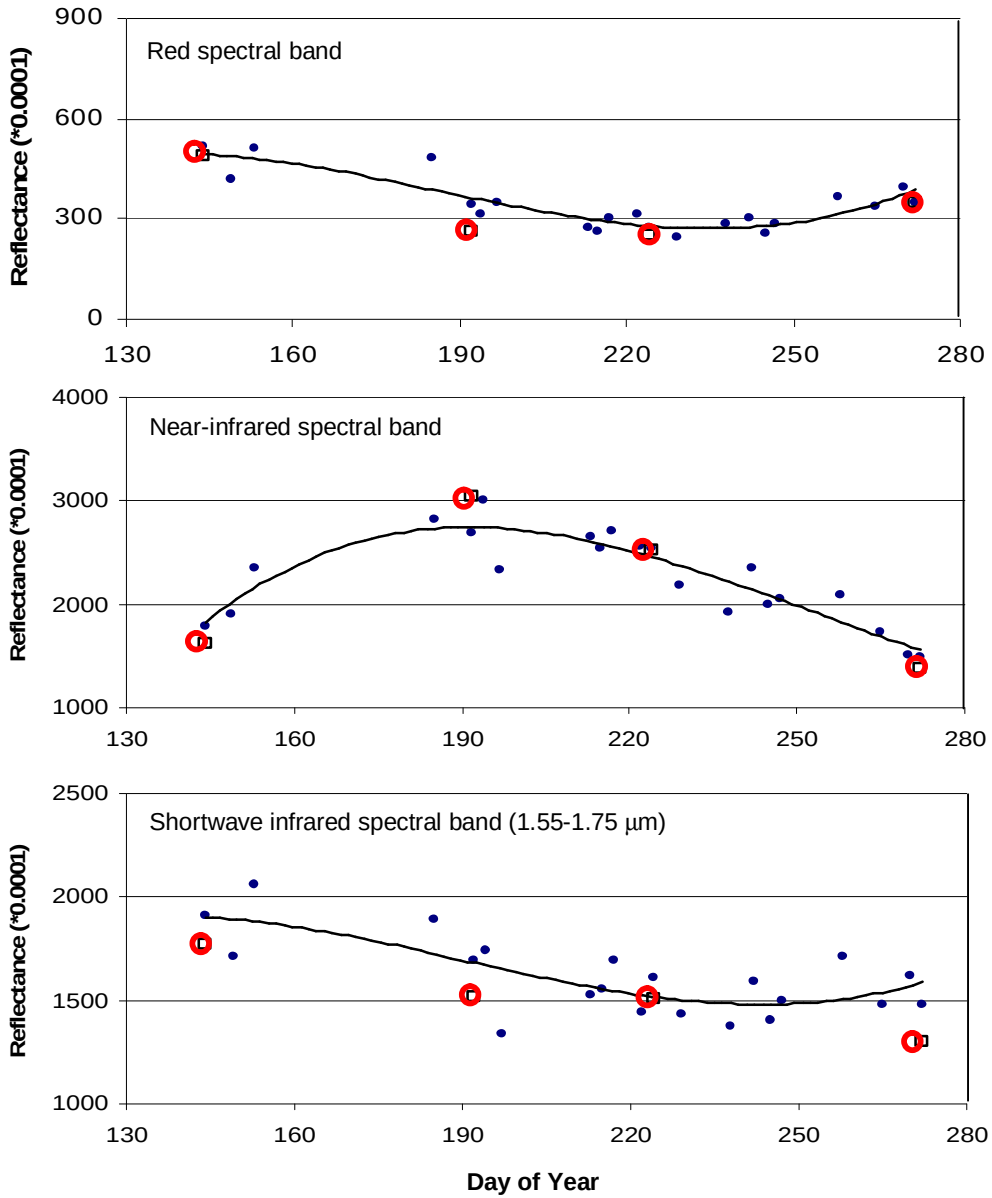
ETM+ Comparison with MODIS



Saskatchewan, Canada

- Landsat (LEDAPS) reflectance
- MODIS daily reflectance (highest QA observations)

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LEDAPS Disturbance Mapping

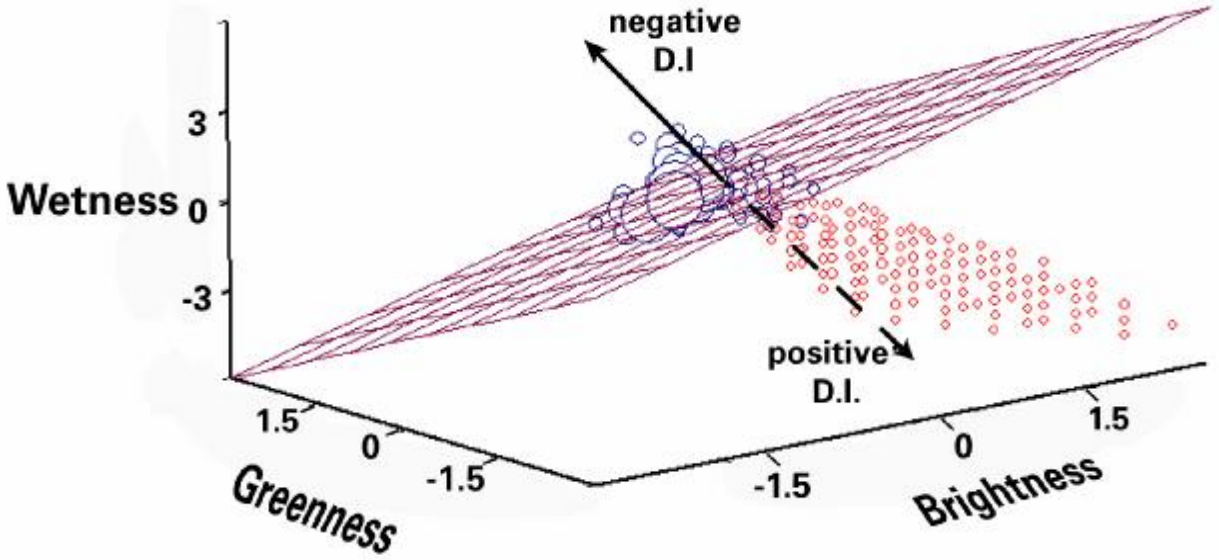
Initial Goal: stand-clearing disturbances (harvest, fire) and secular changes in forest cover

Two approaches to mapping disturbance:

1. **"Disturbance Index"**: semi-empirical spectral index developed by Sean Healey and Warren Cohen, USDA Forest Service.

2. Matching **spectral trajectories** from canopy reflectance models to retrieve physical canopy parameters (D. Peddle/F. Hall/F. Huemmrich)

Disturbance Index: $Brightness_{rescaled} - (Greenness_{rescaled} + Wetness_{rescaled})$



$$Brightness_{rescaled} = (B - \mu_{forest})/\sigma_{forest}$$

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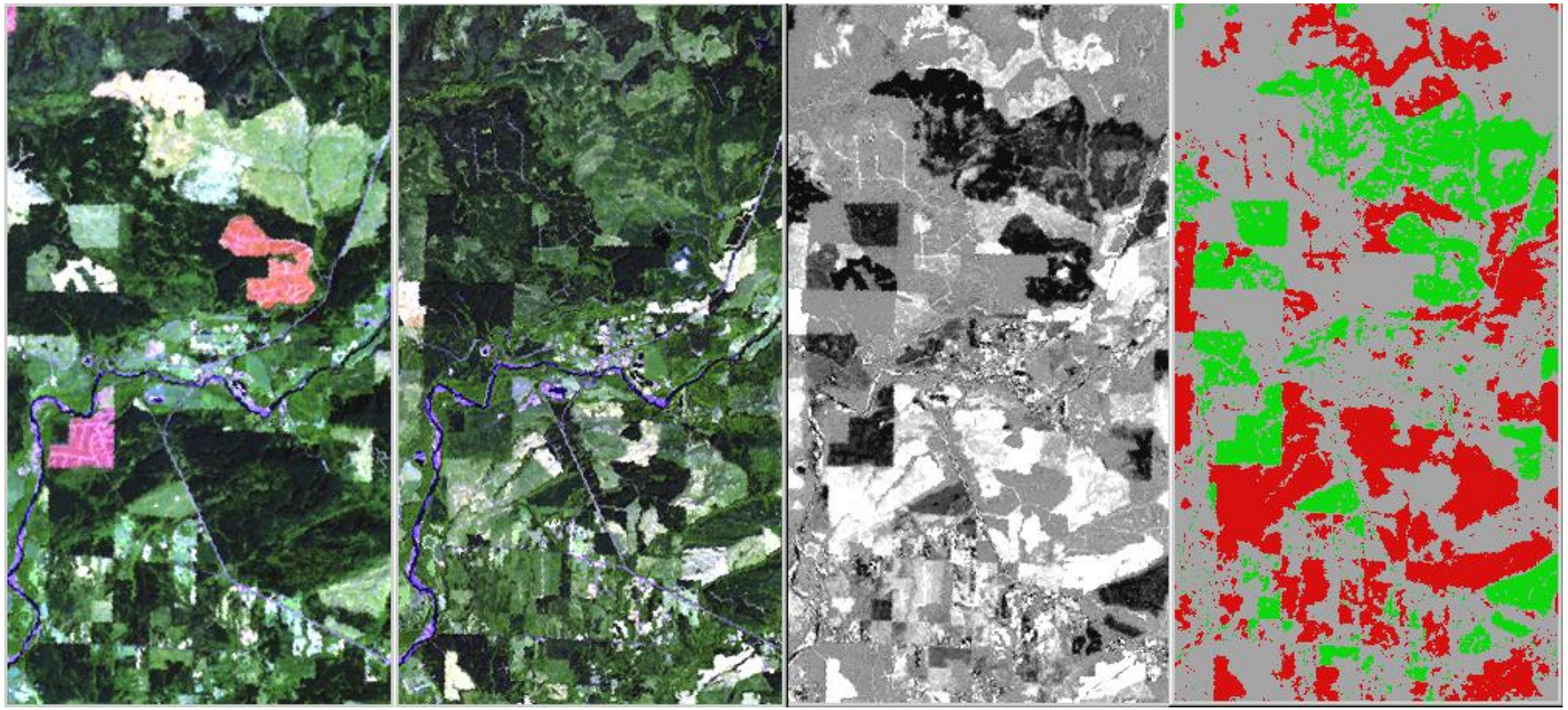
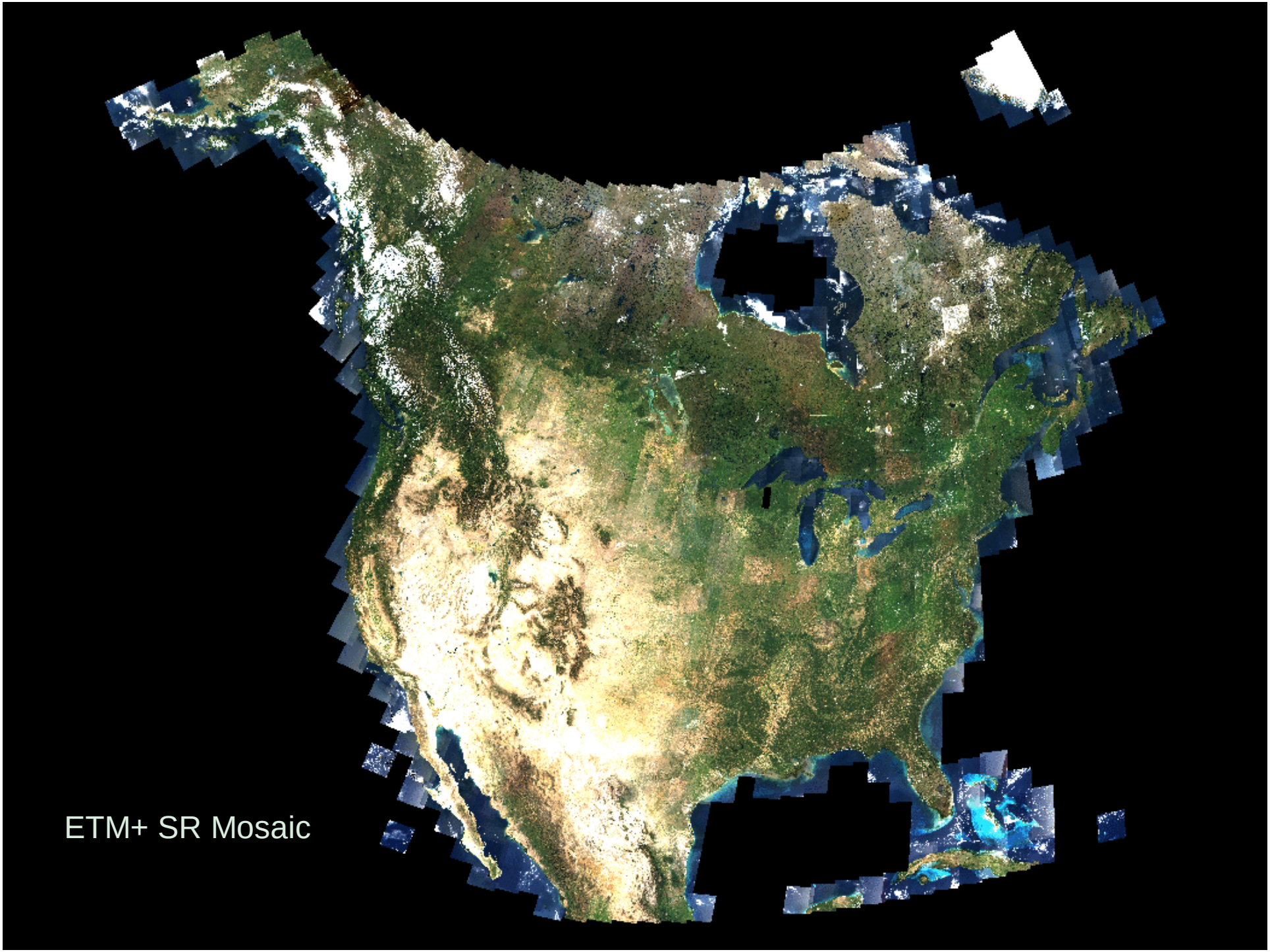
Disturbance Index Example

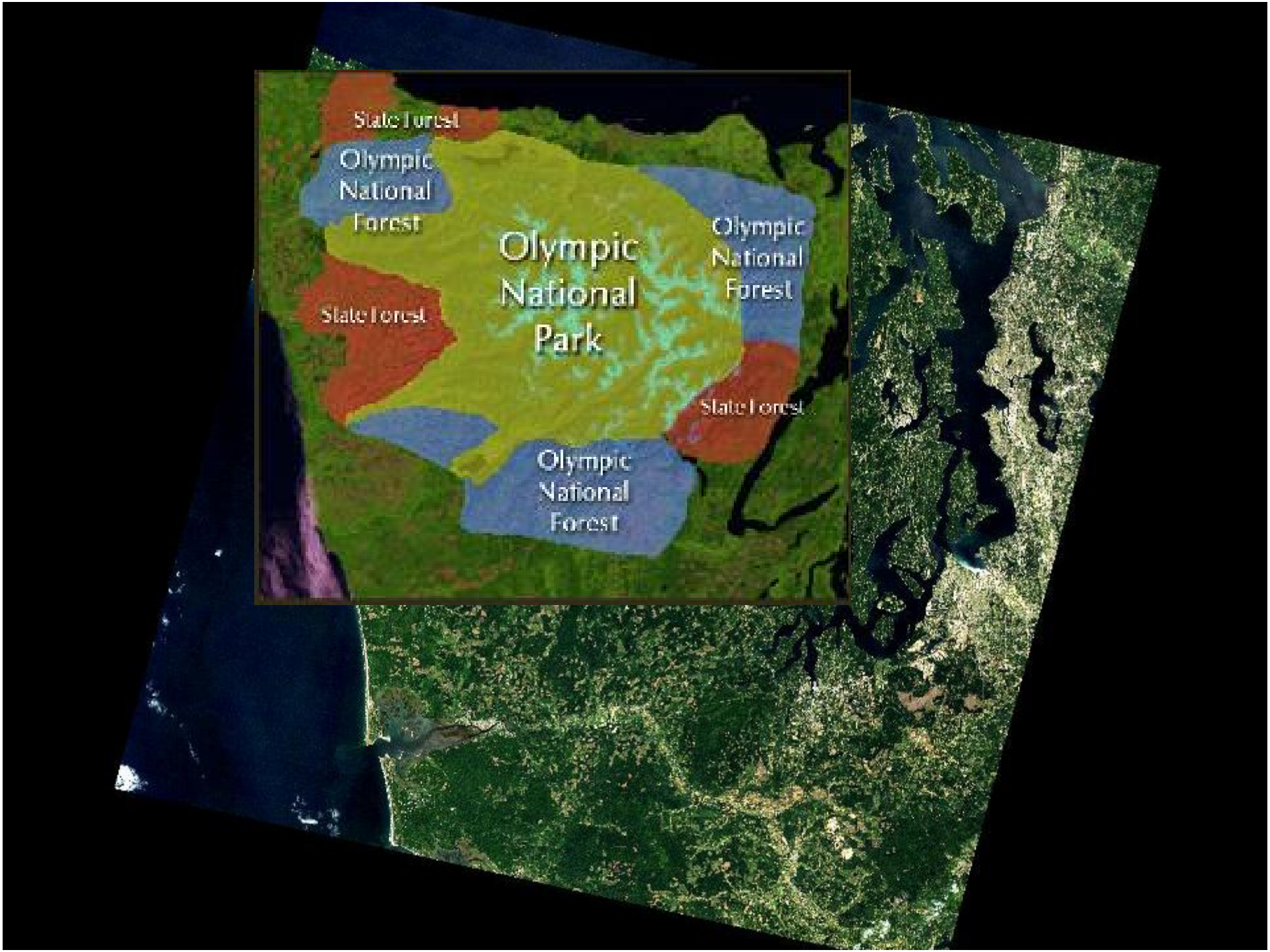
Olympic Peninsula

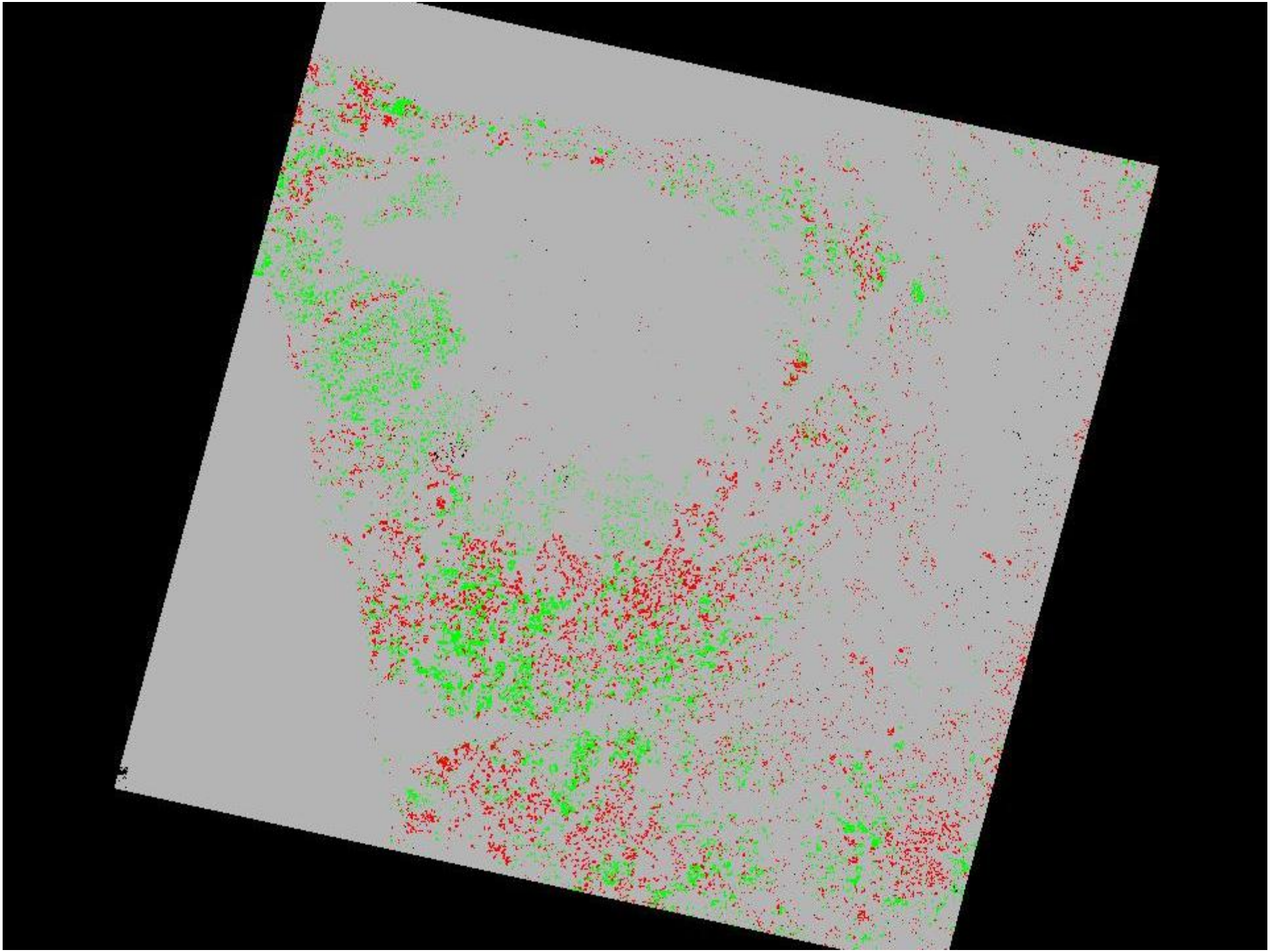


1988 2000 Disturbance Index Change Map

5km


ETM+ SR Mosaic


State Forest
Olympic National Forest
Olympic National Park
Olympic National Forest
State Forest
State Forest
Olympic National Forest



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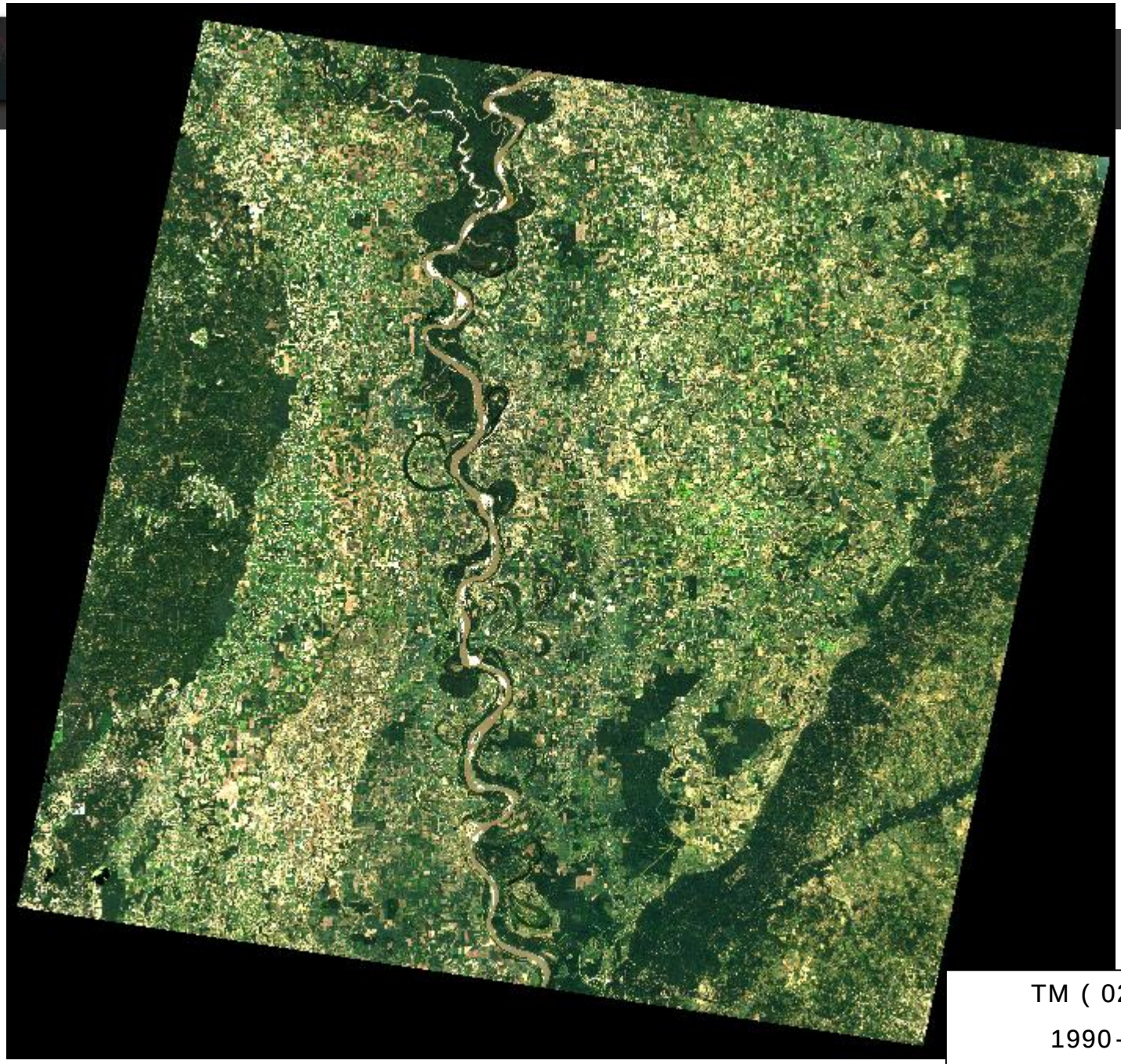

TM (023,037)

1990-08-20

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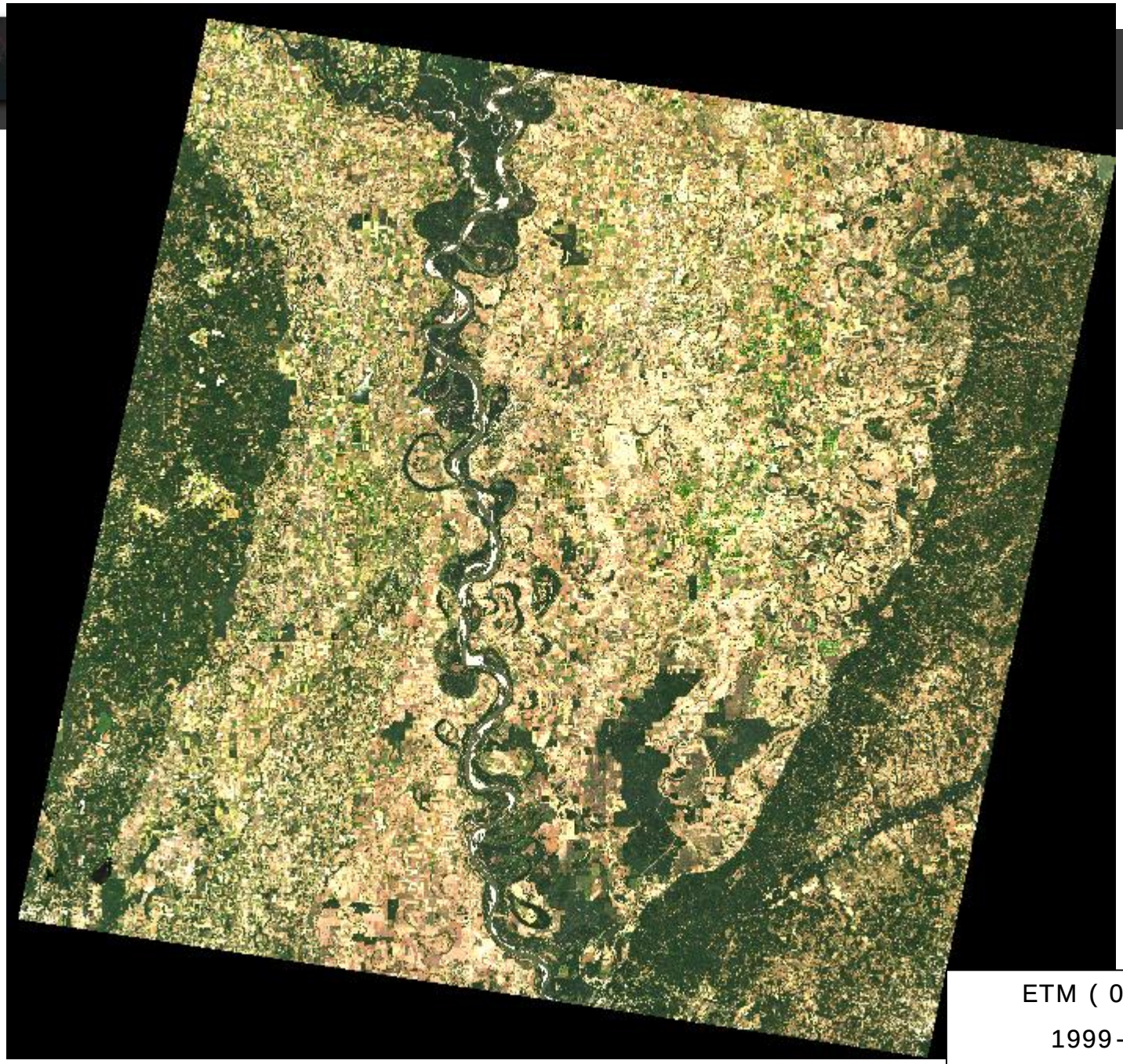

ETM (023,037)

1999-09-22

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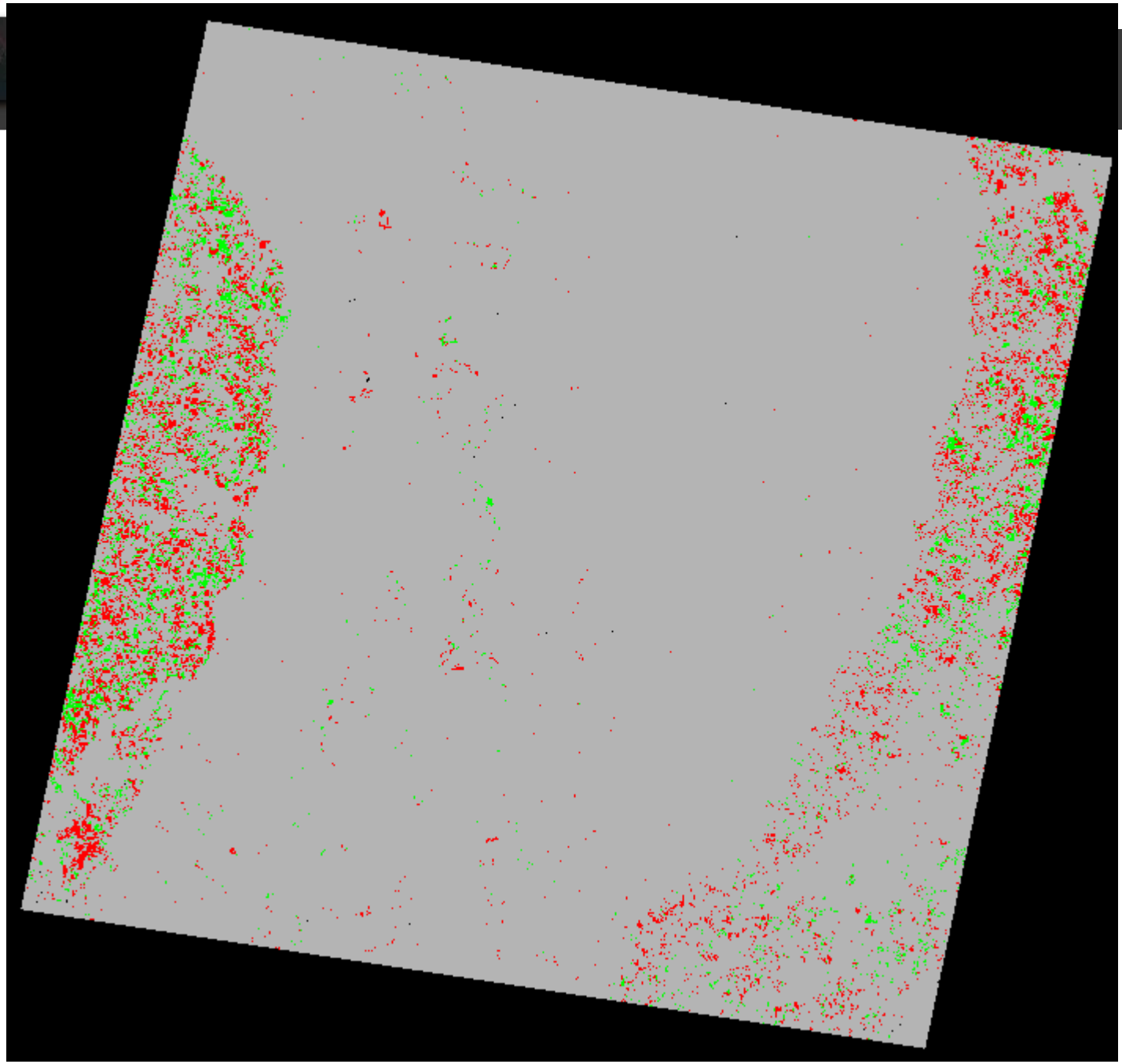

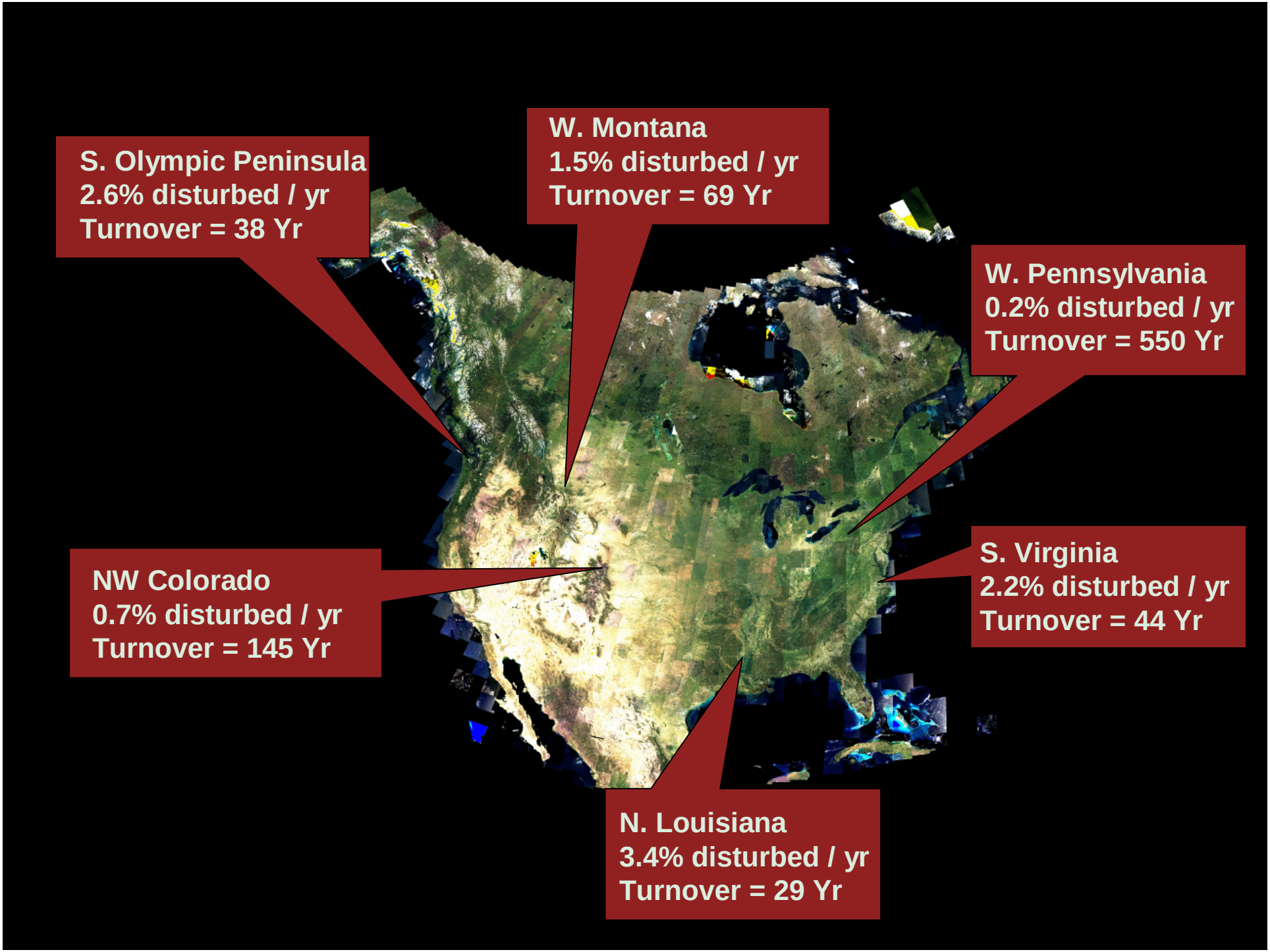
S. Olympic Peninsula
2.6% disturbed / yr
Turnover = 38 Yr
W. Montana
1.5% disturbed / yr
Turnover = 69 Yr
W. Pennsylvania
0.2% disturbed / yr
Turnover = 550 Yr
NW Colorado
0.7% disturbed / yr
Turnover = 145 Yr
S. Virginia
2.2% disturbed / yr
Turnover = 44 Yr
N. Louisiana
3.4% disturbed / yr
Turnover = 29 Yr

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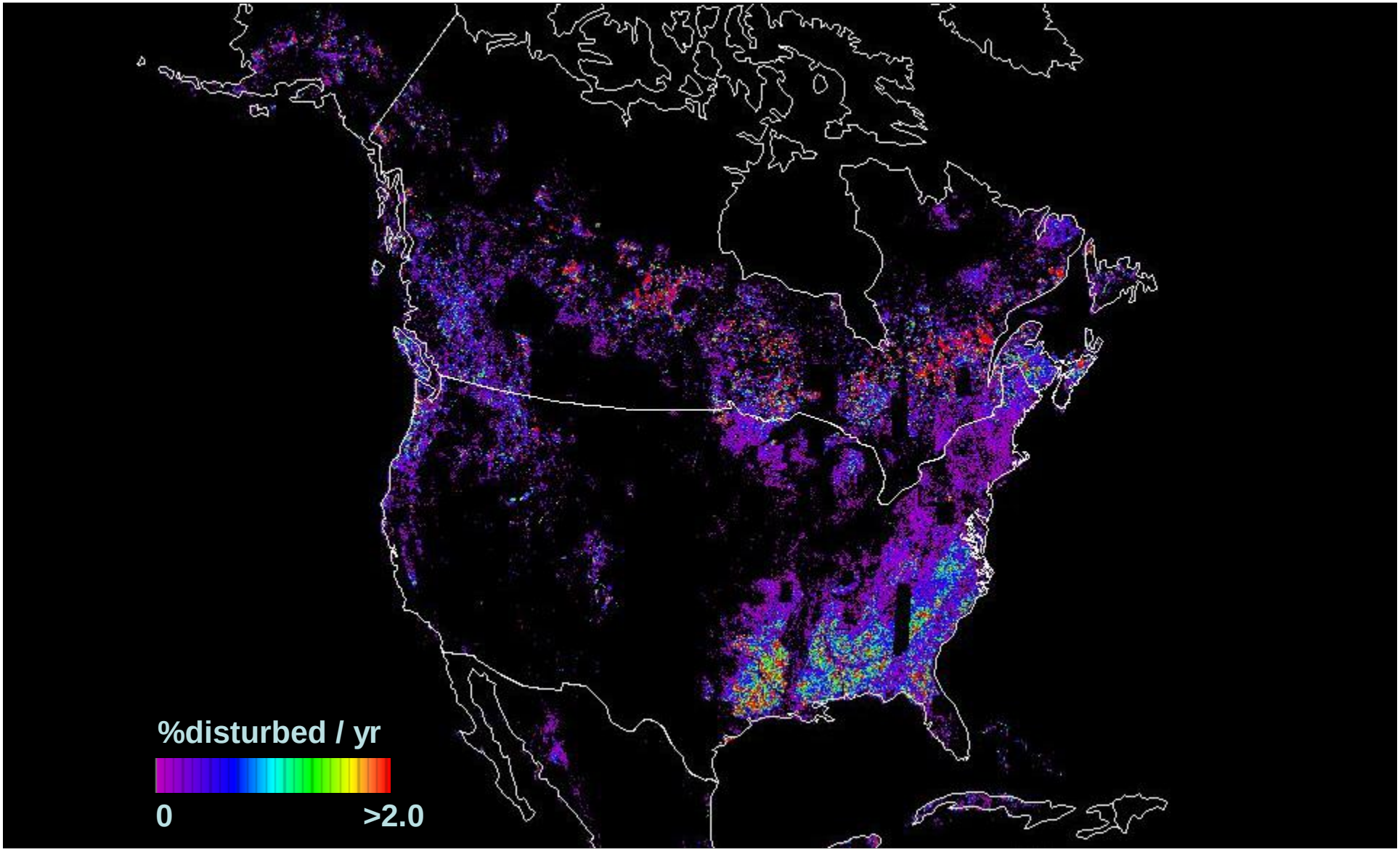
Forest Disturbance



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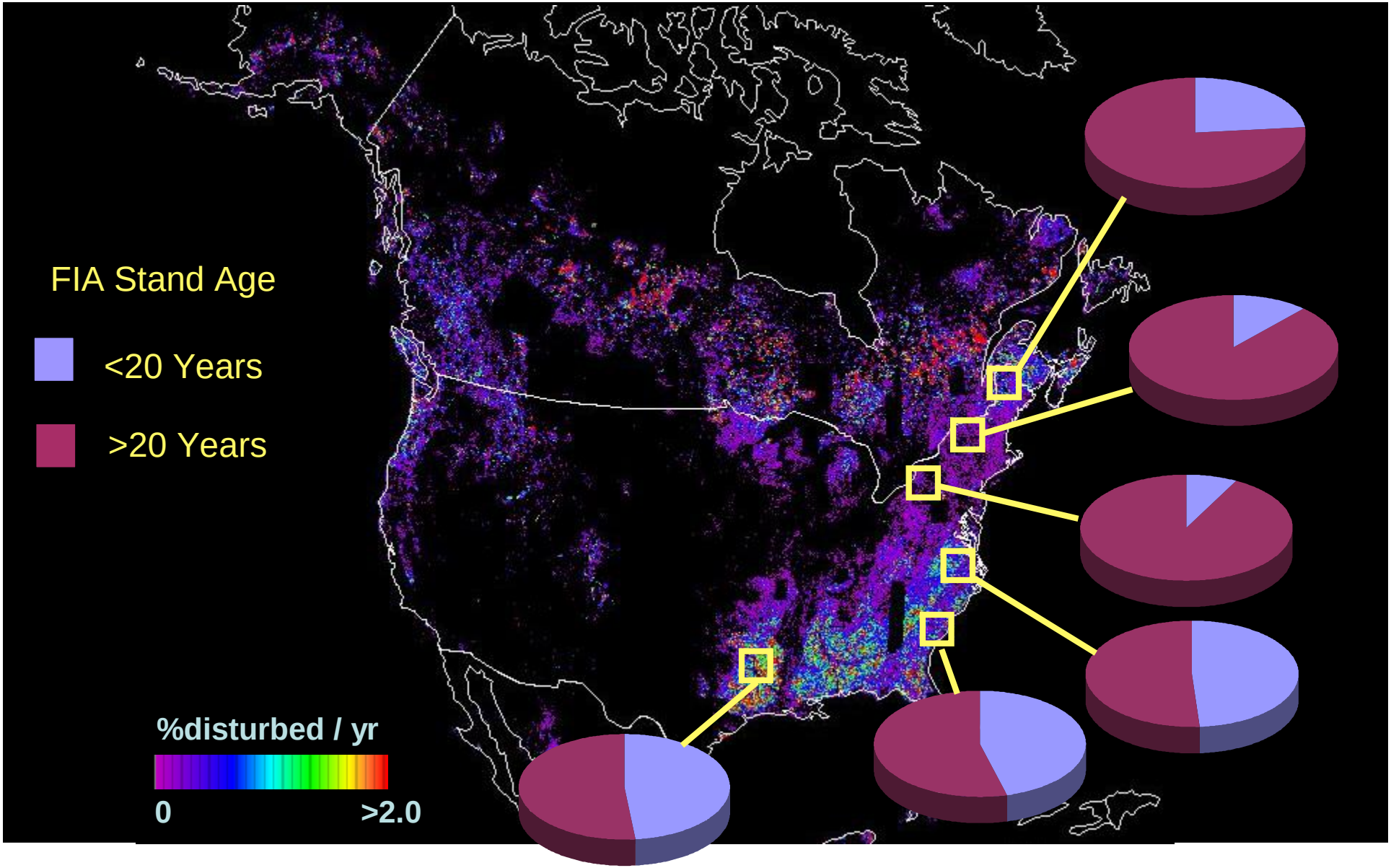

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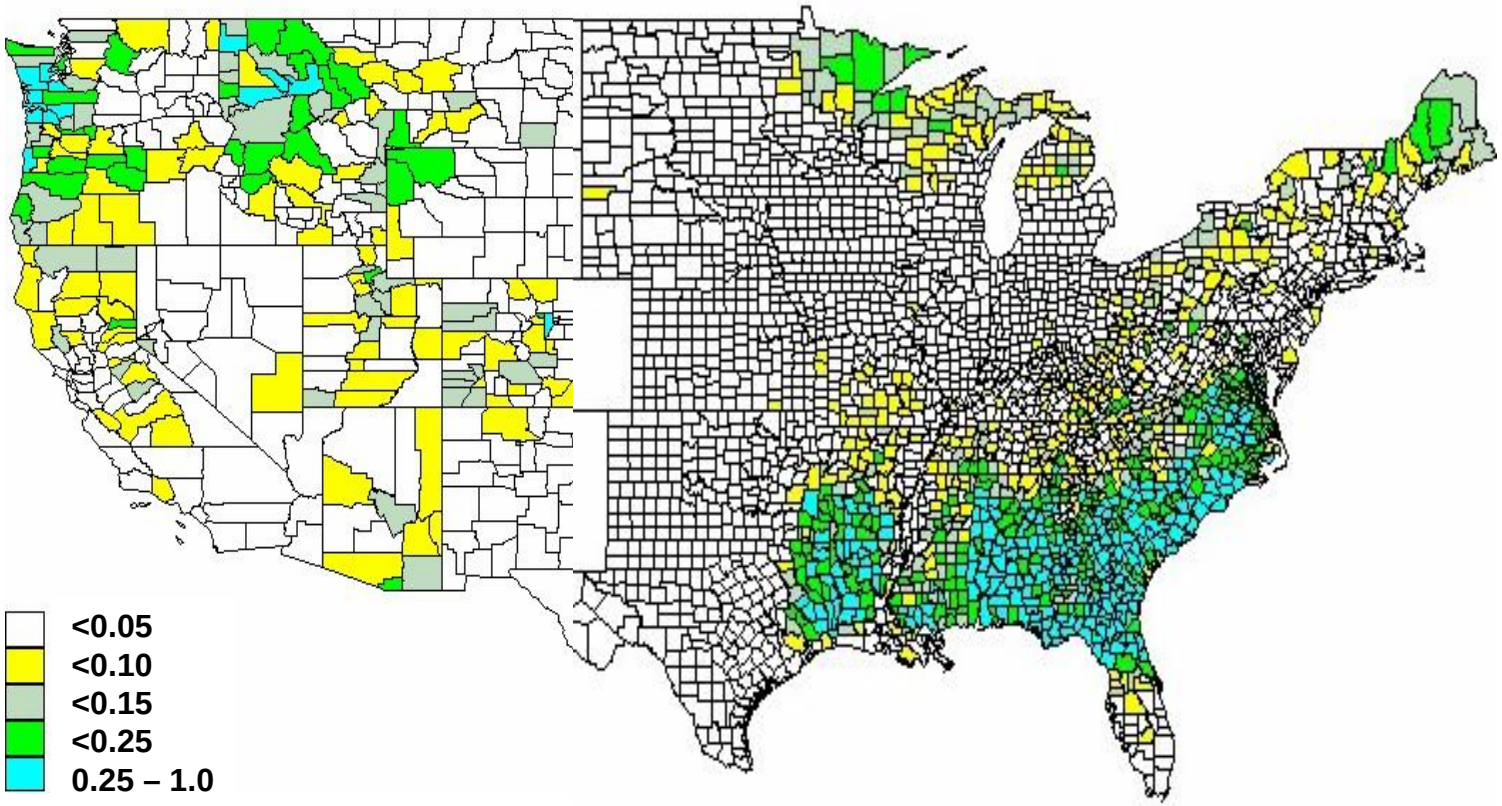
FIA Comparisons

The attribute of interest is Area of forestland(hectares).
Filters: with a stand age from 0 to 20 years,
Area of forestland(hectares) divided by the total area of land in each County code(hectares). .



Fraction of county area occupied by forests < 20 Years Old

Lessons Learned

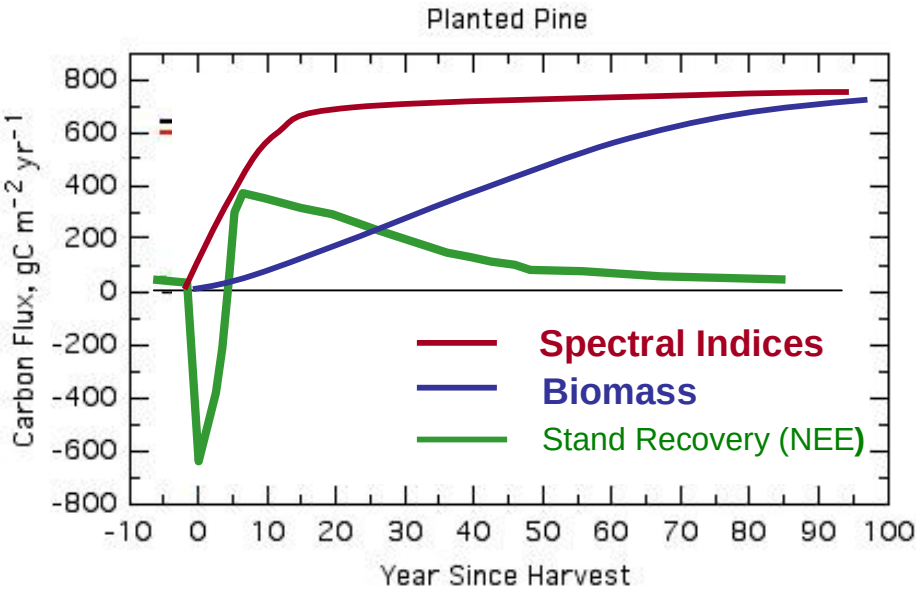
Ten year refresh intervals are too long

3-5 years for mapping clear cuts
1-2 years for mapping thinning
<1 year for defoliation (insects, storm damage)

Time Series Approaches for Satellite Analysis

Process and Re-process Data

What is “regrowth” anyway?



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Conclusions and Next Steps

Disturbance rates vary widely

- up to 3-4% per year in Southeast, PNW, Maine
- lower rates in Rockies, Northeast

Year-to-year variability small in absolute terms (~1%) but can be large in relative terms (~25%).

Next steps:

- continued formal validation of disturbance products
- merging of “wall-to-wall” and sampling results
- characterization of biomass accumulation due to recovery and its spatial variability

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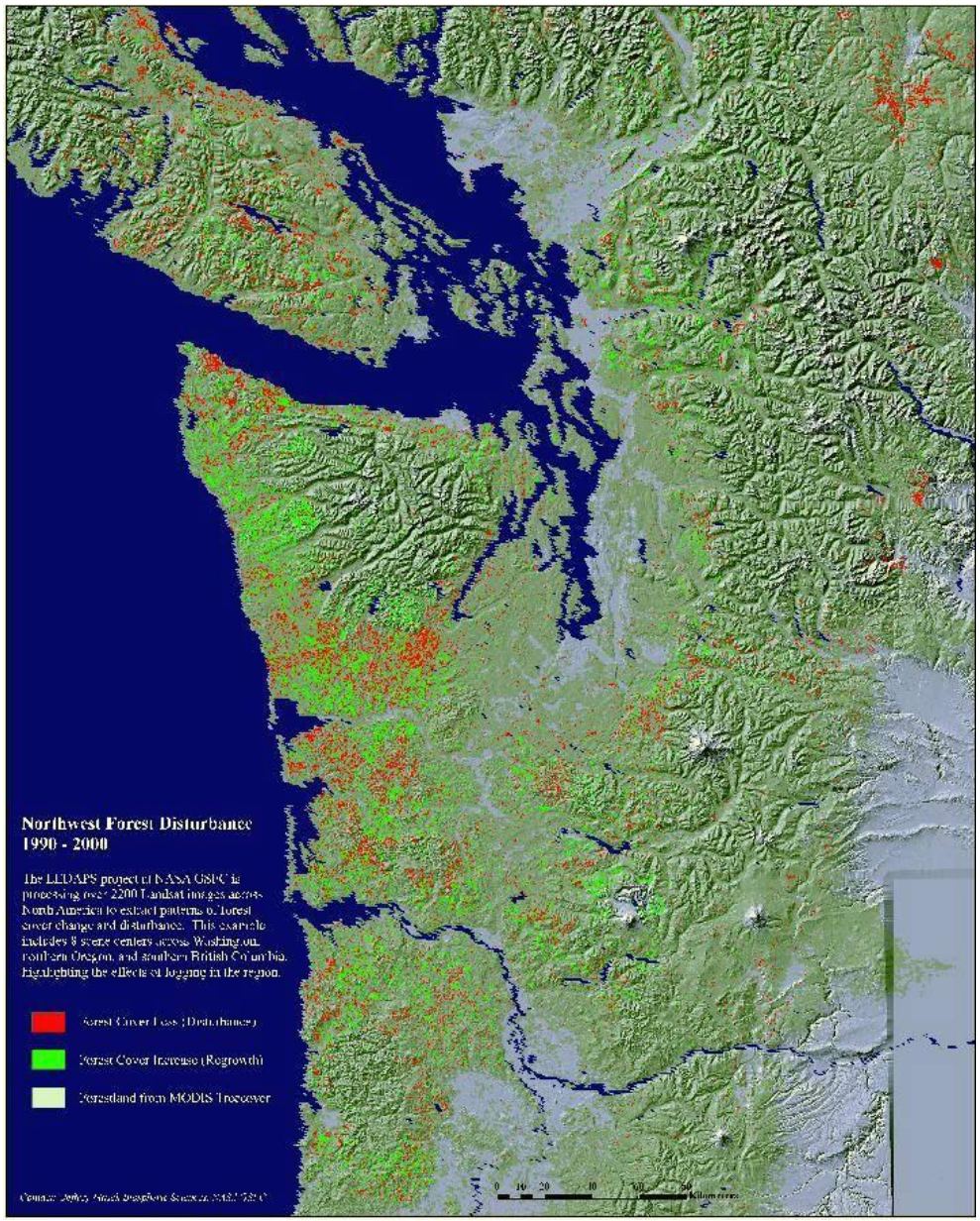

Thank You